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PROPOSED LETTER TO THE EDITOR

MEASUREMENT OF THE CESIUM-CESIUM TOTAL CROSS SECTION BY ATOMIC BEAM TECHNIQUES

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The cesium-cesium total cross section was first measured by Estermann et al.[1] The value they obtained (2350 Å^2) is unusually large for an atomic cross section, but it might be predicted on the basis of the large cesium-cesium dispersion energy constant (2200×10^{-60} (erg)(cm^6)) computed by Fontana.[2] The current interest in cesium for gaseous electronic devices has prompted a remeasurement of this cross section, and the initial results are reported in this letter.

Figure 1 shows the essential details and geometry of the experimental apparatus. The main oven O, the scattering chamber SC and the scattering chamber reservoir SCR are machined from solid blocks of high purity copper. The SC and the SCR are connected by a thin-walled stainless-steel tube. Each of these components is equipped with ac heaters that are used to maintain the desired local temperatures. An extensive iron-constantan thermocouple system moniters and controls the temperatures of each of the components during the experimental runs. The beam slits are cut into 0.051-mm-thick stainless-steel shim stock by an electron beam bombardment technique. The detector D is a surface ionization type employing a 0.053-mm-diameter tungsten filament. The particle current is measured by a Cary Model 31 Electrometer whose output feeds a strip chart recorder. The apparatus is mounted in a 32-in.-diameter stainless-steel vacuum chamber that operates typically in the 1×10^{-7} torr range. Liquid nitrogen cold trapping and baffling are used to lower the concentration of cesium in the critical areas of the apparatus.

[redacted]

High purity cesium (99.95%)[3] contained in vacuum-loaded pyrex capsules was used as the source material for both the main beam and the scattering vapor. After a thorough bakeout of the apparatus (300° C for at least 8 h), the temperature of the beam oven 0 was maintained at 163° C and the scattering chamber was held at 110° C. The temperature of the cesium reservoir (SCR) was varied between 0° and 60° C during each experimental run. This temperature range provided sufficient cesium vapor density in the scattering chamber to attenuate the total beam between 0 and 50 percent. Each time the cesium reservoir temperature was returned to 0° C, the total beam returned to within ±2 percent of its initial value. Typical total beam currents were of the order of 10^{-9} A.

Accurate alignment of the slit assemblies by optical methods was confirmed during the experimental runs by the measurement of the total beam profile. The measured width at half intensity was 0.36 mm as compared to the calculated width of 0.33 mm. The angular resolution of the apparatus estimated on the basis of Kusch's criteria[4] is 3.3 min.

The density of target particles in the SC was measured by blocking the main beam from the oven with the shutter F_1 and by measuring the resultant particle current issuing from the SC. The background level of the detector was determined throughout each run by blocking both the total beam and the scattering chamber particle current. Since the accomodation coefficient for cesium on most metal surfaces is close to one, we are reasonably certain that the velocity distribution of the particles issuing from the SC is characteristic of the SC temperature.[5] From these measurements, along with the kinetic theory equations governing effusive flow, the particle density of the cesium vapor present in the SC could be determined at each point in the attenuation of the main beam.

A typical plot of the log of the total beam current versus the absolute magnitude of the scattering chamber particle density is presented in Fig. 2. The cesium-cesium cross section was obtained from the slope of the straight line utilizing the hard sphere collision analysis of Rosin and Rabi,[6] which takes into account the velocity distributions of both the beam and the scattering gas particles.

The cross section measured for the five runs made to date are given in Table I. The average value of the cross section determined thus far is 2040 Å^2, which is consistent with Estermann's et al[1] value of 2350 Å^2 if allowance is made for the angular resolution of the two experiments. The average relative velocity during the runs is 3.5×10^4 cm/sec. We conservatively estimate the error in the absolute magnitude of the equivalent hard sphere cross section to be 20 percent which is due entirely to the problems associated with the proper determination of the density of the cesium vapor in the scattering chamber.

REFERENCES

1. I. Estermann, S. N. Foner, and O. Stern, Phys. Rev. 71, 250 (1947)
2. P. R. Fontana, Phys. Rev. 123, 1865 (1961)
3. Analysis supplied by Dow Chemical Co.
4. P. Kusch, Jour. Chem. Phys. 40, 1 (1964)
5. J. H. McFee, P. M. Marcus, and I. Estermann, Rev. Sci. Instr. 31, 1013 (1960)
6. S. Rosin and I. I. Rabi, Phys. Rev. 48, 373 (1935)

TABLE I. - CROSS SECTION MEASUREMENTS

Run	Measured cesium-cesium cross section, $Å^2$
1	1790
2	2090
3	1845
4	2250
5	2225

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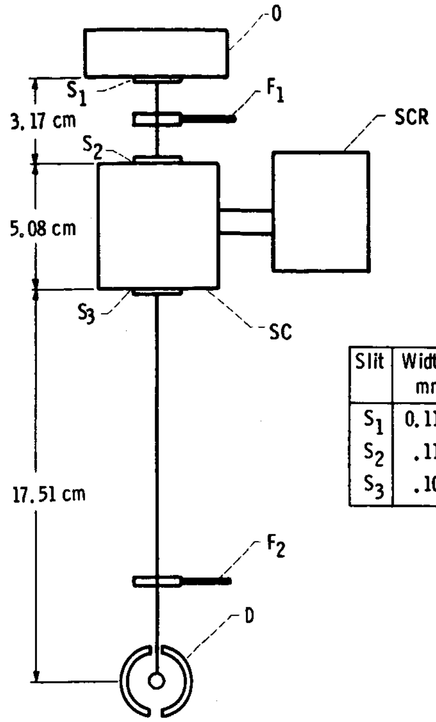

Slit	Width, mm	Height, mm
S_1	0.114	5.08
S_2	.114	5.08
S_3	.104	5.08

Figure 1. - Diagram (not to scale) of atomic beam apparatus showing geometric location of components. Main oven, O; scattering chamber, SC; scattering chamber reservoir, SCR; surface ionization detector, D; beam shutters, F_1 and F_2.

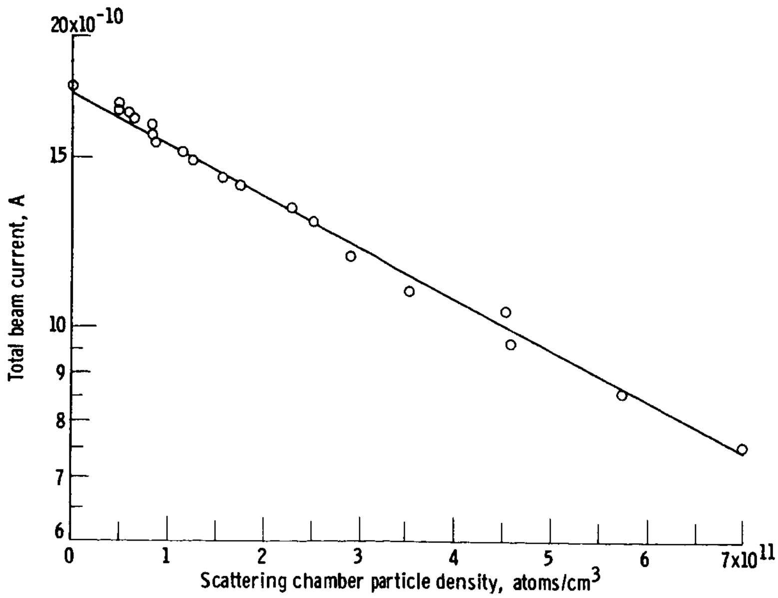

Figure 2. - Total beam attenuation for run 3.